Chapter 6

Conclusions

In this dissertation, I introduced a novel technique to incorporate primaries and surface-related multiples into imaging. The technique can properly address the challenges of multiple imaging such as the appearance of crosstalk artifacts in the image. In regions with complex subsurface geology, this technique has been shown to improve imaging in poorly illuminated areas.

In Chapter 2, I discussed the theory of joint imaging of up- and down-going signal for an ocean-bottom dataset. The benefits and characteristics of imaging with either type of signal were highlighted. The formulation of data-domain linearized inversion, also known as least-squares reverse-time migration, was presented. I demonstrated how high quality images can be obtained with results from a 2D synthetic and the 2D Cascadia field datasets.

In Chapter 3, I applied the method developed in Chapter 2 onto the 3D Deimos ocean-bottom field dataset from the Gulf of Mexico. I introduced three techniques to improve the robustness of applying least-squares reverse-time migration onto the field dataset. Salt-dimming data weighting was introduced to address some of the issues associated with a strong background data in the study area. The complex salt structure in the study area created shadow zones in the image. I used a target-oriented data-reweighting to emphasize deeper parts of the image near the salt. I incorporated the prestack extended-angle domain filtering in the least-square reverse-time migration algorithim to suppress some of the unwanted noise in the image space. Instead of treating the primary image and the mirror image separately, I combined the information from the two sets of data coherently using joint least-squares reverse-time migration (joint LSRTM). The result of the application showed that joint least-squares reverse-time migration of primary and mirror signals is superior to conventional single-mode imaging.

In Chapter 4, I discussed the theory for imaging higher-order surface-related multiples in an ocean-bottom dataset — mirror and double-mirror reflections. The procedure for constructing the modeling and migration operator for the higher-order surface-related multiples was presented. The technique utilizes the data as an areal source, which provides equal sensitivity to the background velocity when compared to imaging using the primary signal. I demonstrated improvements in illumination and noise suppression with results from a 2D synthetic dataset.

In Chapter 5, I applied the method developed in Chapter 4 onto a 3D Gulf of Mexico ocean-bottom node dataset to image with the mirror and double-mirror reflection energy. Salt-dimming data weighting and target-oriented data reweighting introduced in Chapter 3 was incorporated into the joint least-squares reverse-time migration process. The result of the application shows that crosstalk is reduced and illumination is improved in the image. In particular, areas near and underneath a complex salt structure are better illuminated. Joint LSRTM eliminate the need to separate out surface-related multiples in the down-going ocean-bottom data and can be a viable alternative to traditional processing.

In this thesis, I introduced a method that highlights the benefits of using surface-related multiples in imaging while addressing the problem of crosstalk artifacts in the image. Interesting future work would include surface-related multiples in the velocity model building process. In particular, for a region with complex salt structures, joint LSRTM might provide better illumination of salt boundaries and subsequently salt picking.